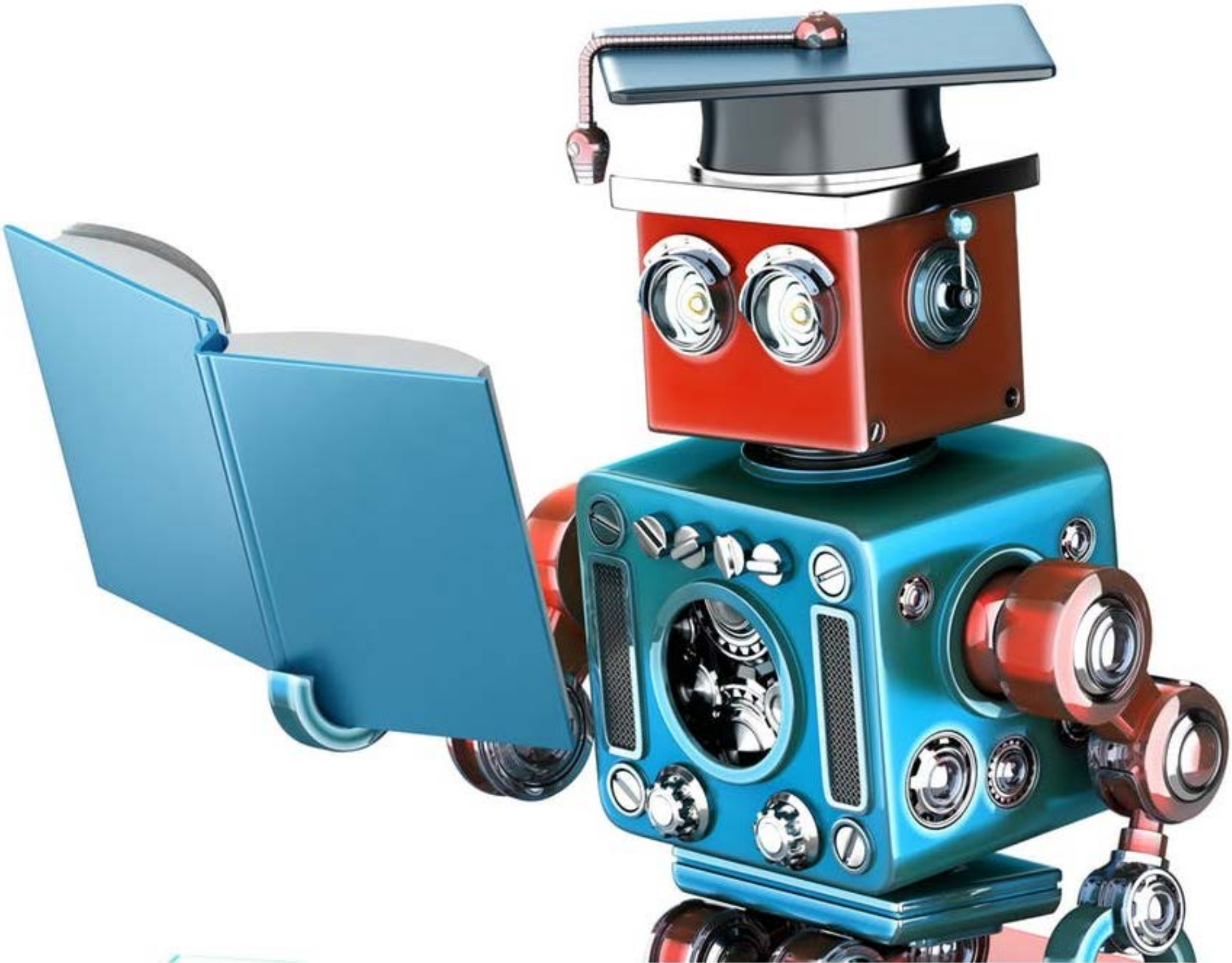
COMP 308
ARTIFICIAL INTELLIGENCE
PART 1 – INTRODUCTION

Njeri Ireri

Jan – April 2020



We Shall Discuss

- Intelligence
- What is A.I?
- Foundations of A.I - Multi-disciplinary domain
- A Brief History
- Approaches to A.I
- A.I Applications

Intelligence

- Dictionary definition

(1) : the ability to learn or understand or to deal with new or trying situations : **REASON**; *also* : the skilled use of reason

(2) : the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria (as tests)

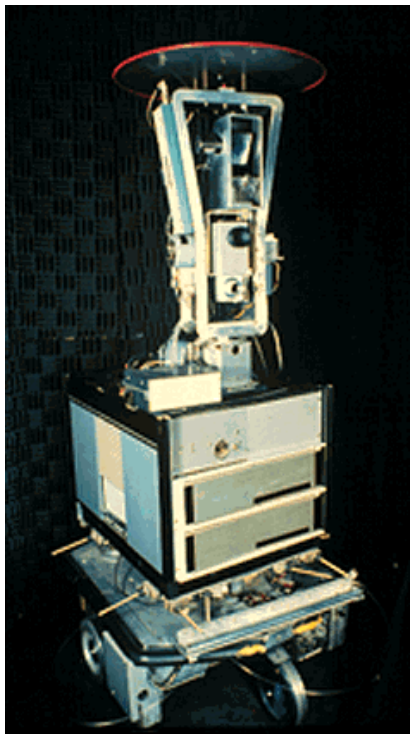
-Merriam-Webster's Collegiate Dictionary

- Main ideas concerned with
  - Thought processes and reasoning
  - Behavior

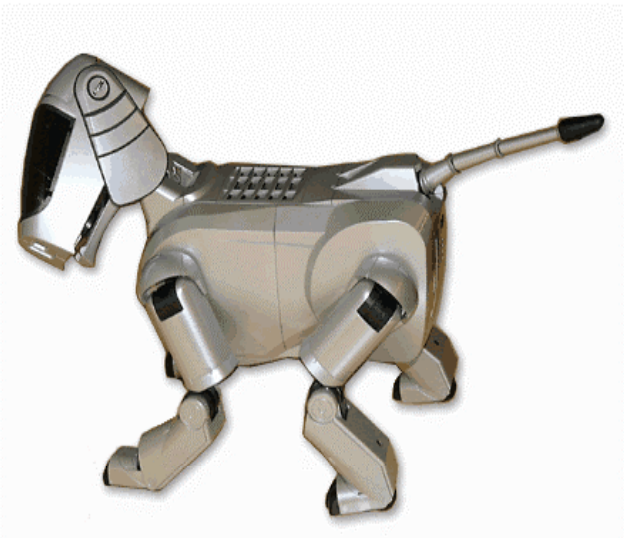
Intelligence – 2 views

- **Intelligence = Autonomous movement**
- Intelligence = Thinking

Vaucanson
18th century



Shakey (1970)
Stanford Research Institute



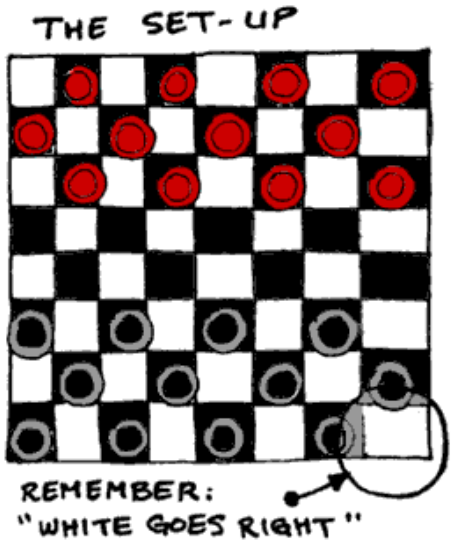
SONY Aibo (1998)

Intelligence – 2 views

- Intelligence = Autonomous movement
- **Intelligence = Thinking**

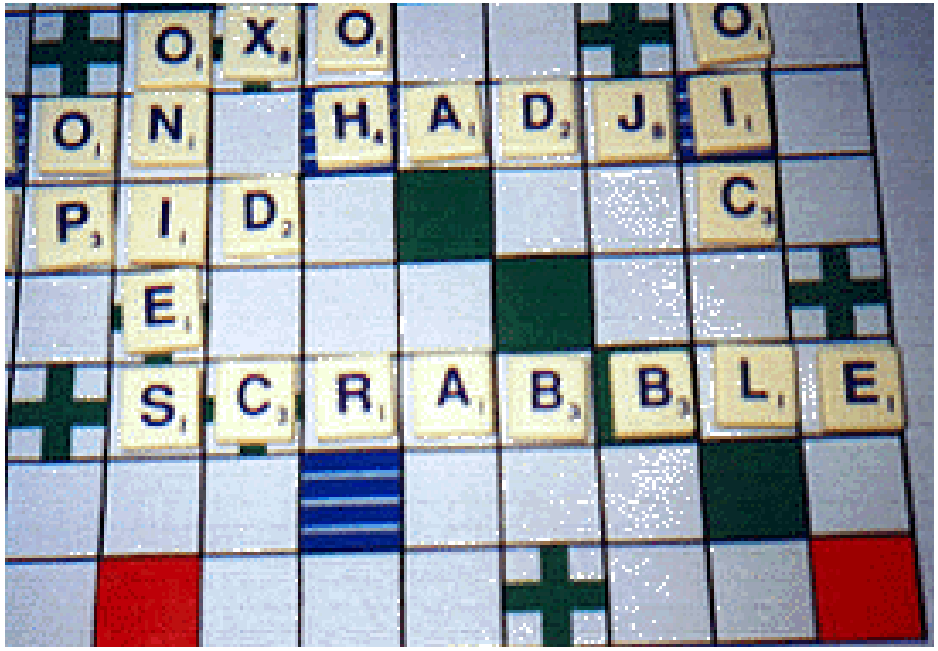
Deep Blue defeats Garry Kasparov (1997)

Playing Games: Draughts



Is a computer more intelligent
if it beats you in a game of draughts?

Playing Games: Scrabble



Is a computer more intelligent
if it beats you in a game of scrabble?

Playing Games: Jigsaw

Is a computer more intelligent if it solves the puzzle faster than you do?

Finding Your Way: Maps

Travel from one town or village to another within shortest time and cheapest; e.g. Cyangugu to Kigarama

Intelligence

- Types of intelligence (Multiple intelligence theory, Howard Gardner)
  - Linguistic-verbal intelligence
  - Logical-Mathematical intelligence
  - Musical intelligence
  - Spatial intelligence
  - Intrapersonal intelligence
  - Interpersonal intelligence
  - Naturalist intelligence
  - Bodily-Kinesthetic intelligence

Theoretical foundations for recognizing different talents and abilities in people

- "What makes life interesting, however, is that we don't have the same strength in each intelligence area, and we don't have the same amalgam of intelligences. Just as we look different from one another and have different kinds of personalities, we also have different kinds of minds."

Defining Artificial Intelligence

- There is no agreed definition of the term artificial intelligence. However, there are various definitions that have been proposed. These are considered below.
  - AI is a study in which computer systems are made that **think like human beings**. Haugeland, 1985 & Bellman, 1978.
  - AI is a study in which computer systems are made that **act like people**. AI is the art of creating computers that **perform functions that require intelligence when performed by people**. Kurzweil, 1990.
  - AI is the study of how to make computers **do things which at the moment people are better at**. Rich & Knight
  - AI is a study in which **computers that rationally think** are made. Charniac & McDermott, 1985.
  - AI is the study of **computations that make it possible to perceive, reason and act**. Winston, 1992

Defining Artificial Intelligence

- AI is the study in which **systems that rationally act** are made. AI is considered to be a study that **seeks to explain and emulate intelligent behaviour in terms of computational processes.** Schalkeoff, 1990.
- AI is considered to be a branch of computer science that is concerned with the **automation of intelligent behavior.** Luger & Stubblefield, 1993.
- ...

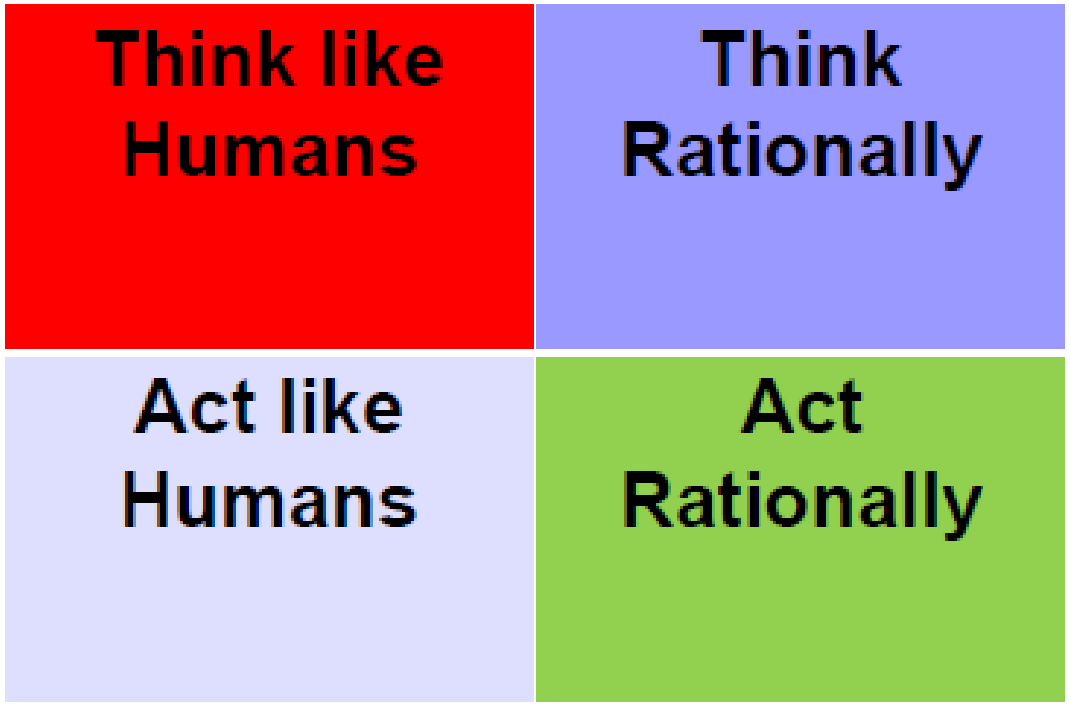
- Main ideas concerned with
  - Thought processes and reasoning
  - Behavior

Defining Artificial Intelligence

- Based on different definitions by different authors, the definitions of AI can be organized into 4 main categories

  A system that can:

  - Think like humans
  - Act like humans
  - Think rationally
  - Act rationally



Defining Artificial Intelligence

	"Like People"	"Rationally"
Think	Cognitive Science	Laws of Thought
Act	Turing Test	Rational Agents

What is A.I?

- **'Systems that think like humans':**
  - The exciting new effort to make computers think … machines with minds
  - The automation of activities that we associate with human thinking e.g. decision making, problem solving, learning etc.

- Thinking humanly: Cognitive Modeling
  - Goal: Develop precise theories of human thinking
  - We need a way to determine how we think:
    - Through introspection
    - Through psychological experiments
  - How to validate? Requires
    - Predicting and testing behavior of human subjects (topdown)
    - Direct identification from neurological data (bottom-up)
  - Cognitive Sciences now distinct from AI

What is A.I?

- Thinking humanly: Cognitive Modeling
  - **Problem:**
    - Identifiability: It may be impossible to identify the detailed structure of human problem solving using only externally available data.
    - "Optimal" performance is an excellent predictor of human performance in most routine tasks.

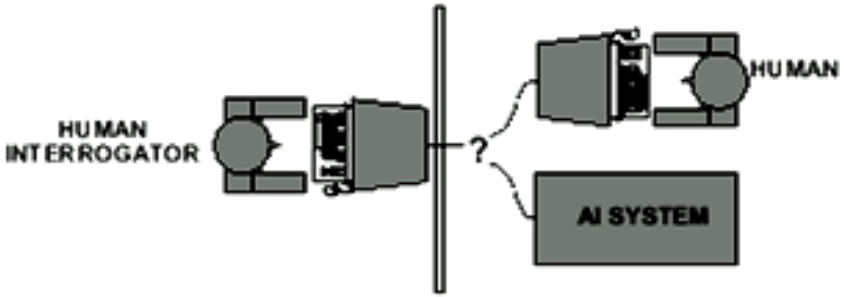
What is A.I?

- **'Systems that act like humans':**
  - The art of making machines that perform functions that require intelligence when performed by people
  - The study of how to make computers do things which, at the moment, people do better

- Acting humanly: Turing Test
  - Alan Turing (1950) "Computing machinery and intelligence":
    - "Can machines think?" ←→ "Can machines behave intelligently?"
    - Can Computer fool a human interrogator?

What is A.I?

- Acting humanly: Turing Test



- Anticipated all major arguments against AI in following 50 years
- Suggested major components of AI:
  - Natural language processing
  - Knowledge representation
  - Automated reasoning
  - Machine learning

What is A.I?

- Acting humanly: Turing Test
  - **Problems:**
    - Tends to focus on human-like errors, linguistic tricks, etc. Does not produce the most useful computer programs
    - Turing test is not reproducible, constructive, and amenable to mathematic analysis
    - What about physical interaction with interrogator and environment?
      - **Total Turing Test:** Requires physical interaction and needs perception (vision) and actuation (robotics)

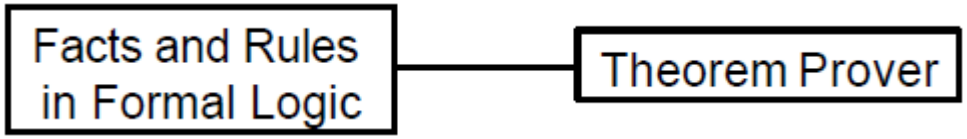
What is A.I?

- **'Systems that think rationally':**
  - Study of mental faculties through the use of computational models
  - Study of the computations that make it possible to perceive, reason and act

- Thinking Rationally: "Laws of thought" (The Logical Approach)
  - Aristotle: what are correct arguments/thought processes?
  - Several Greek schools developed various forms of *logic*: *notation* and *rules of derivation* for thoughts; may or may not have proceeded to the idea of mechanization
  - Direct line through mathematics and philosophy to modern AI

What is A.I?

- Thinking Rationally: "Laws of thought"
  - Ensure that all actions performed by computer are justifiable ("rational")



  - Rational = Conclusions are provable from inputs and prior knowledge

  - **Problems:**
    - Not all intelligent behavior is mediated by logical deliberation- Representation of informal knowledge is difficult
    - Hard to define "provable" plausible reasoning
    - Combinatorial explosion: Not enough time or space to prove desired conclusions
    - What is the purpose of thinking? What thoughts should I have?

What is A.I?

- **'Systems that act rationally':**
  - The study and design of intelligent agents
  - AI is concerned with intelligent behavior artifacts

- Acting rationally: rational agent
  - Rational behavior = the thing that which is expected to maximize goal achievement, given the available information
  - Does acting rationally have to necessarily involve thinking?
    - blinking reflex
    - or reflexive withdrawal of hand from hot oven
  - Not necessary … but thinking should be in the service of rational action

What is A.I?

- Acting rationally: rational agent
  - **Claim:** "Rational" means more than just logically justified. It also means "doing the right thing"

Rational agents do the best they can given their resources

very few resources — lots of resources

no thought	limited, approximate reasoning	Careful, deliberate reasoning
"reflexes"		

  - Adjust amount of reasoning according to available resources and importance of the result
  - This is one thing that makes AI hard

So, Why Study A.I?

- Now that we know what A.I is, why is it exciting?
  - tries to understand intelligent entities, therefore we learn more about ourselves
  - strives to build intelligent entities, these are useful and interesting e.g. robots, …..
  - still a fairly new discipline and has lots of opportunities, good ideas have not already been taken by Galileo, Newton, Einstein and the rest. There's still openings for a full-time Einstein
  - regularly cited as the "*field I would most like to be in*" by scientists in other disciplines

..but the Objectives of A.I

- Understand how living beings behave, think, learn
- Engage in experiments by building artificial systems
- Derive applications for robotics and computers

Foundations of AI, a Multi-disciplinary Domain

- i.e. the main disciplines that have contributed ideas viewpoints and techniques that we find useful in AI

- Philosophy:
  - Can formal rules be used to draw valid conclusions?
  - How does the mental mind arise from a physical brain?
  - Where does knowledge come from?
  - How does knowledge lead to action?
- Mathematics; algorithms: formal representation and proof
  - What are the formal rules to draw valid conclusions?
  - What can be computed?
  - How do we reason with uncertain information?
- Computer Engineering
  - How can we build an efficient computer?

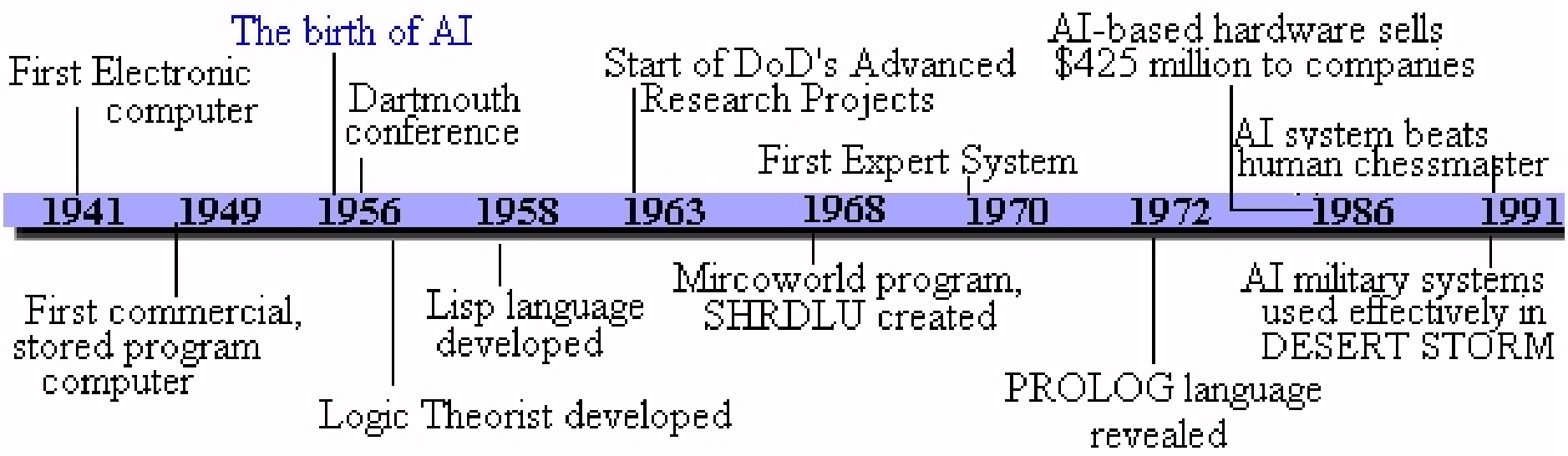
Foundations of AI, a Multi-disciplinary Domain

- Economics: Utility, decision theory
  - How should we make decisions so as to maximize payoff?
  - How should we do this when others may not go along?
- Neuroscience:
  - How do brains process information?
- Psychology
  - How do humans and animals think and act?
- Control theory and cybernetics:
  - How can artifacts operate under their own control?
- Linguistics:
  - How does language relate to thought?

History of A.I?

- ‘Gestation of AI’ (1943-1955)
  - 1943 McCulloch & Pitts: Boolean circuit model of brain
  - 1950 Turing’s “Computing Machinery and Intelligence”
  - 1950s Early AI programs, including Samuel’s checkers (draughts) program
  - Newell & Simon’s Logic Theorist, Gelernter’s Geometry Engine
- 1956 Birth of Artificial Intelligence - Dartmouth meeting: “Artificial Intelligence” adopted
- 1966–74 A dose of reality - AI discovers computational complexity, Neural network research almost disappears
- 1969–79 Early development of knowledge-based systems
- 1980–88 Expert systems industry booms
- 1988–93 Expert systems industry busts: “AI Winter”
- 1985–95 Neural networks return to popularity
- AI becomes a science (1987 – Present)
- Emergence of intelligent agents (1995 – Present)

History of A.I?



A.I: Evaluation

- AI has tended to succeed more in expert tasks (theorem proving, game playing, medical diagnosis)
- Than in mundane tasks (route planning, recognizing people and objects, communicating in natural language, navigating round objects etc.)

Approaches to A.I

- Strong AI
  - Aim: to build machines that can truly reason and solve problems; machines that are self aware and whose overall intellectual ability is indistinguishable from that of a human
  - Products not yet realized
  - The **Chinese room experiment** by John Searle refutes the Strong AI (Turing Test) claim that:
    - "The appropriately programmed computer with the right inputs and outputs would thereby have a mind in exactly the same sense human beings have minds"

- Weak AI
  - Aim: create some form of AI that cannot truly reason and solve problems … but can act as if intelligent; machines that simulate human cognition
  - Some success has been reported in this area

The Chinese Room Experiment

- It is a thought-experiment first published in 1980 by American philosopher John Searle
- Searle imagines himself alone in a room following a computer program for responding to Chinese characters that are slipped to him under the door. Searle understands nothing of Chinese, and yet, by following the program for manipulating symbols and numerals just as a computer does, he produces appropriate strings of Chinese characters that fool those outside into thinking there is a Chinese speaker in the room
- The question Searle wants to answer is this: does the machine *literally* "understand" Chinese? Or is it merely *simulating* the ability to understand Chinese? Searle calls the first position "strong AI" and the latter "weak AI" approach

The Chinese Room Experiment

- The narrow conclusion of the argument is that programming a digital computer may make it appear to understand language but does not produce real understanding. Hence the "Turing Test" is inadequate. Searle argues that the thought experiment underscores the fact that computers merely use syntactic rules to manipulate symbol strings, but have no understanding of meaning or semantics.
- The broader conclusion of the argument is that the theory that human minds are computer-like computational or information processing systems is refuted. Instead minds must result from biological processes; computers can at best simulate these biological processes

Approaches to A.I

- Applied AI
  - Aim: produce commercially viable 'smart' systems e.g. a security system able to recognize faces in order to facilitate or deny access to premises
  - Considerably successful
- Cognitive AI
  - Aim: to use computers to test theories on how the human mind works e.g. theories on how we recognize faces, objects etc.

Basic Human Intelligent Behavior

- Perception (Seeing, hearing)
- Reasoning
- Learning
- Understanding Language
- Solving Problems

A.I Application Areas

- General problem solving
  - machine learning, automated reasoning, optimization, resource allocation, planning, scheduling, real-time problem solving, intelligent assistants, internet agents
- Computer Vision and Image recognition
  - Understanding images
- Robotics
  - engineering physical movement
- Natural language processing Natural language understanding
  - understanding written text
- Speech Recognition
  - understanding human speech
- Knowledge Based Systems
  - model human expertise in a limited area

Key Study Areas in A.I and

- Knowledge Based Systems
  - model human expertise in a limited area
- Reasoning
  - Uncertainty: probabilistic approaches
  - Decision theory
- Machine Learning
- Perception
  - Vision, natural language, robotics
- General Algorithms
  - Search, planning, constraint satisfaction
- Applications:
  - Game playing, AI in education, distributed agents

A.I applications – Sample Landmark Projects

- MYCIN
- PROSPECTOR
- Autonomous Land Vehicle in a Neural Network (ALVINN)
- Deep Blue
- Machine Translator Programs
- Robotics
- Data Mining
- ...

Knowledge-based systems

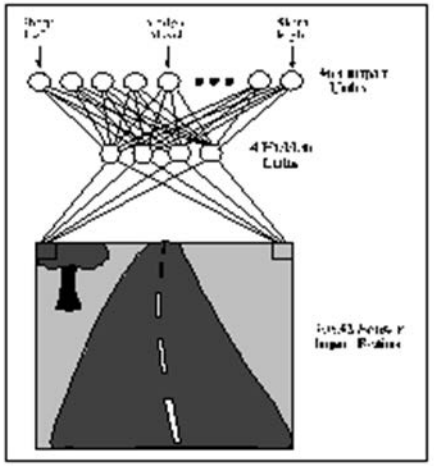
- Medical Diagnosis - MYCIN
  - 1971, A program that could diagnose blood infections. It had 450 rules
  - It identifies bacteria causing severe infections, such as bacteremia and meningitis, and recommends antibiotics

- Mineral Prospecting - PROSPECTOR
  - 1979, A program that with geological data. It recommended exploratory drilling sites that proved to have substantial molybdenum deposits

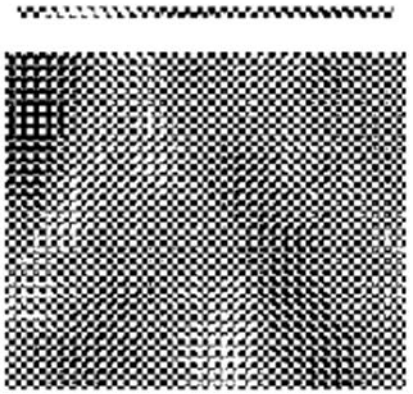
ALVINN

- The Autonomous Land Vehicle in a Neural Network is a perception system which learns to control the NAVLAB vehicles by watching a person drive

  - Created in 1989
  - Drove itself some 2850 miles across the US
  - Drives 70 mph on a public highway



  - 30 outputs for steering
  - 4 hidden units
  - 30x32 pixels as inputs
  - 30x32 weights into one out of four hidden unit

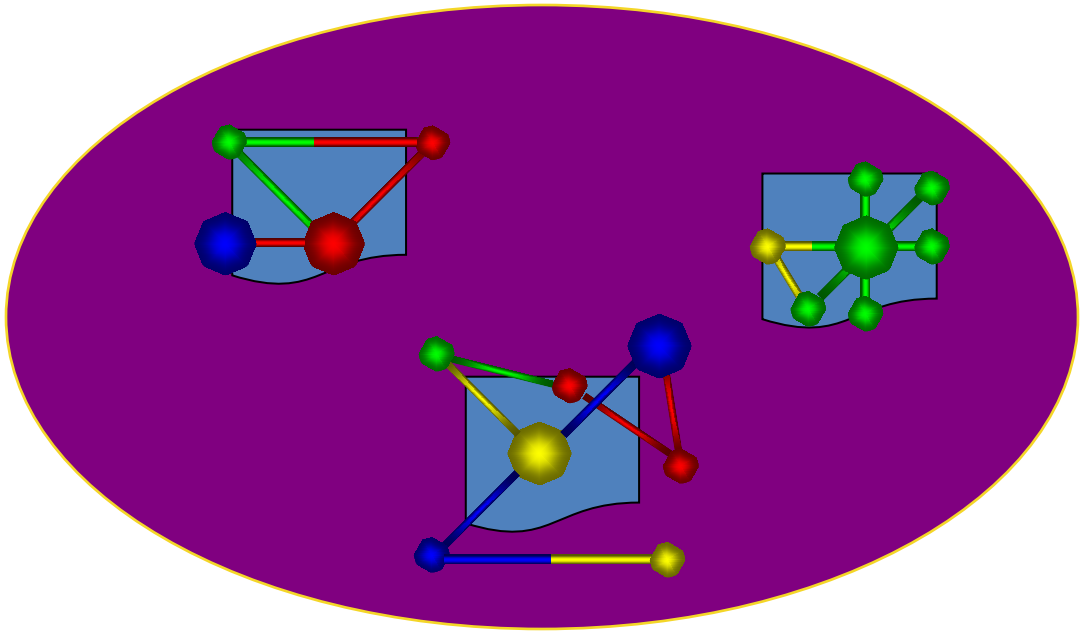


Machine Translator Programs

- Phraselator
  - Used by the US Military in the war in Iraq to quiz POWs, injured, communicate at checkpoints etc.
- Speechlator
  - For use in doctor-patient interviews

Data Mining

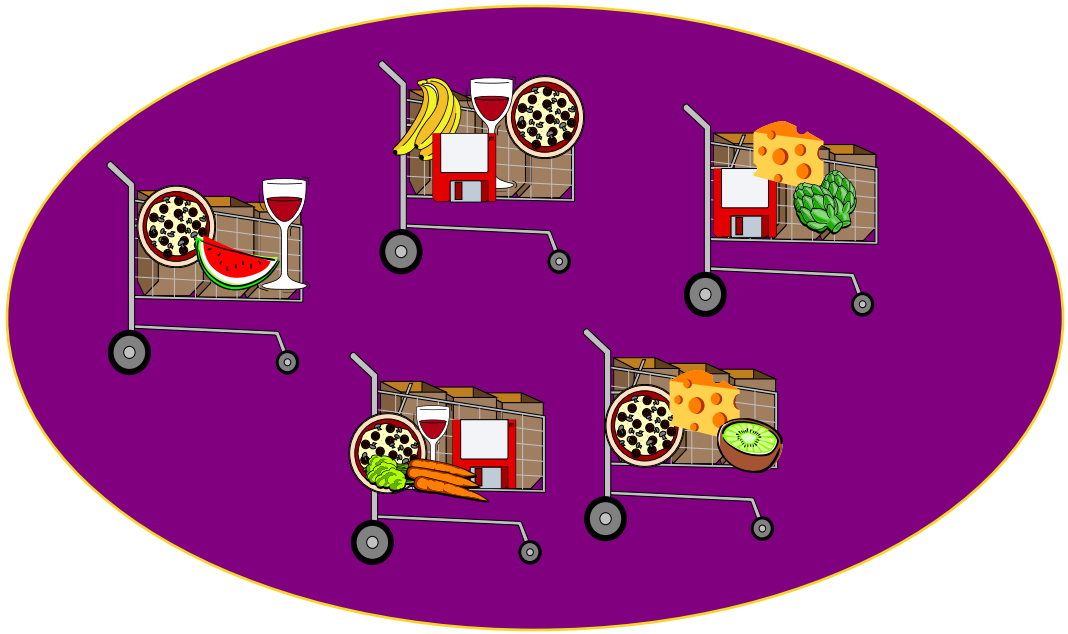
- An application of Machine Learning techniques
  - Data Mining applications exist that examine large pre-existing databases in order to generate new information
  - It solves problems that humans can not solve, because the data involved is too large, noisy ...



Detecting cancer risk molecules is one example.

Data Mining

- A similar application:
  - In marketing products ...

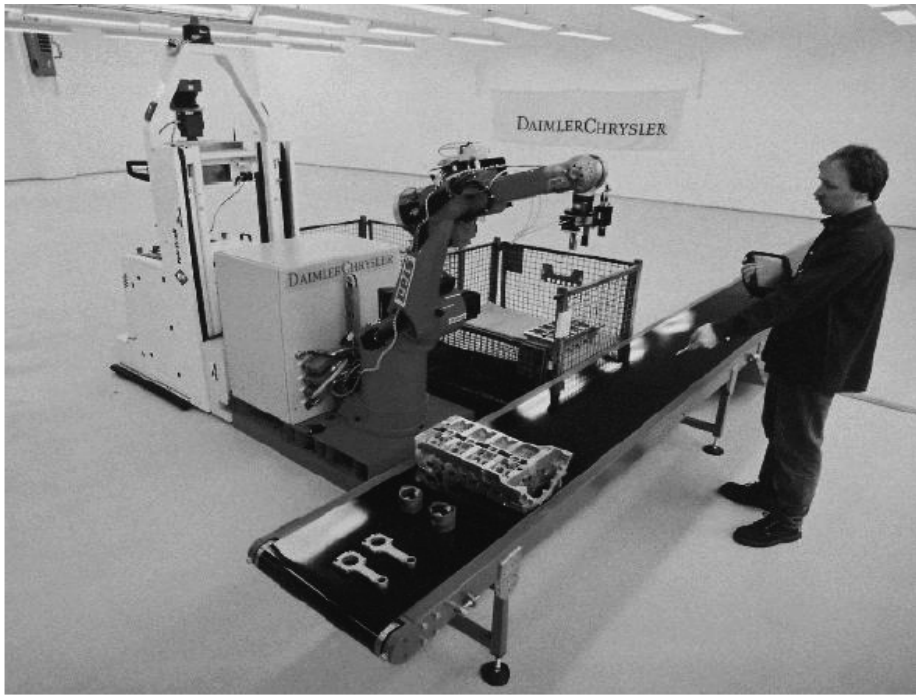


Predicting customer behavior in supermarkets is another.

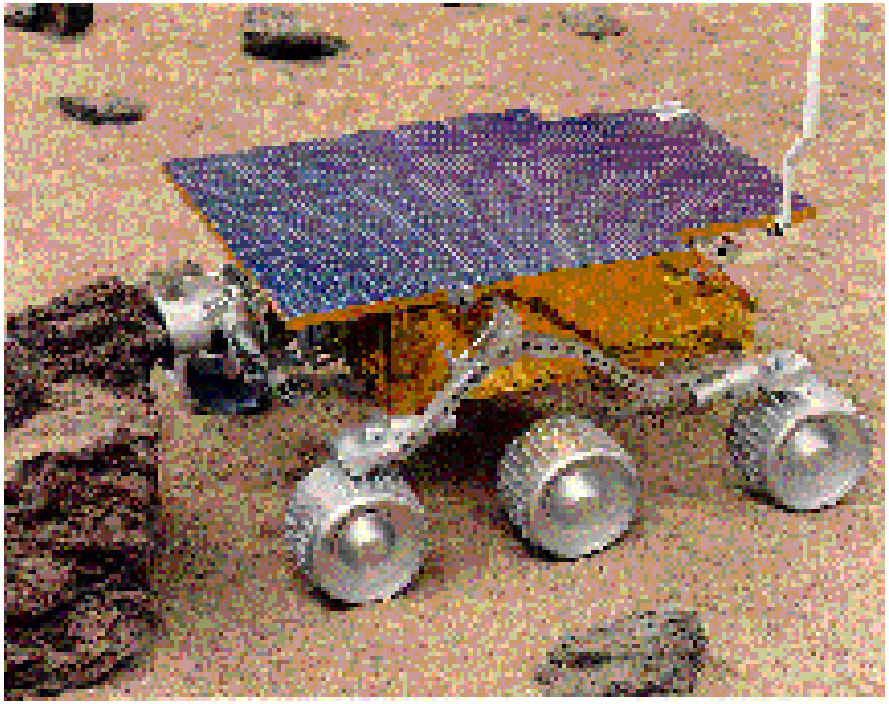
- Fraud Detection
  - 1997, Credit card fraud detection

Robotics

- Traditional Robots



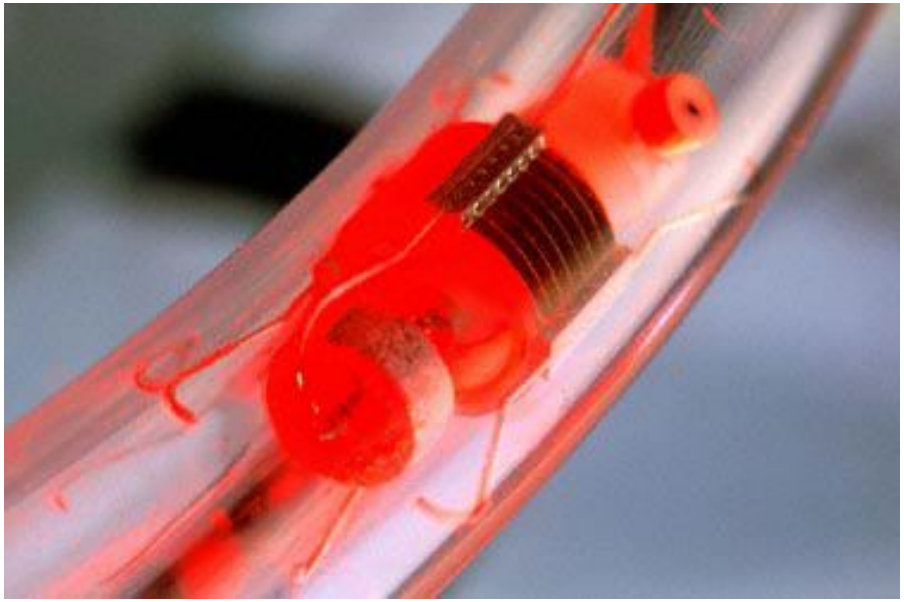
- Mars Rover (1996)
  - Exploring Mars



Robotics

- Wire repair

- Pipe inspector



How far is the field advanced?

- Very far
  - Humanoid robots
  - Natural language interfaces
  - Expert systems

  …
- Not far at all compared to humans
  - Integration?
  - Learning?

Exercise

- Describe the Turing Test
- According to Alan Turing, When does a computer pass the intelligence / Turing test?
  - For the above two, read Chapters 1 & 26 of *Artificial Intelligence: A Modern Approach* by Russell and Norvig
- Search on the internet about Deep Blue and read on it
- Read Garry Kasparov's interview
  - Find this in the slide presentation: *Deep Blue defeats Kasparov*
- www – Look up the ALICE chatting robot (or ELIZA the therapist) on the internet and chat with 'her'. In your opinion is she intelligent?
- Search on the internet on MYCIN or PROSPECTOR, knowledge-based system and read on it. How is knowledge stored?
- In preparation for the next class, look at Chapter 2: Intelligent Agents on book by Russell and Norvig
- Read: Marvin Minsky, Pioneer in Artificial Intelligence, Dies at 88

https://www.nytimes.com/2016/01/26/business/marvin-minsky-pioneer-in-artificial-intelligence-dies-at-88.html

Exercise

- What is Intelligence?
- What is Artificial Intelligence?
- For each of the below sets of statements: Is the latter statement true, and does it imply the former?
  - "Surely computers cannot be intelligent – They can only do what their programmers tell them"
  - "Surely animals cannot be intelligent – They can only do what their genes tell them"
- Discuss the Chinese Room Experiment
- Discuss what an expert system is and give two new examples
- Discuss the various disciplines that contributed to the development of AI
- Discuss the events in the development of AI